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Observational Study to Assess the Radiographic Incidence of Lumbar Spinal Instability in Patients with Low Back Pain in a Tertiary Care Hospital

[1]Jummo Jini and [2]B.K. Singhania

[1]*Department of Neurosurgery, Ramakrishna Mission Hospital, Itanagar, Papum Pare, Arunachal Pradesh 791113, India*

[2]*Department of Neurosurgery, Apollo Multispecilality Hospitals, Kolkata 58, Canal Circular Road, Kadapara, Phool Bagan, Kankurgachi, Kolkata, West Bengal 700054, India*

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Corresponding Author
Jummo Jini,
Department of Neurosurgery, Ramakrishna Mission Hospital, Itanagar, Papum Pare, Arunachal Pradesh 791113, India

Author Designation
[1]Consultant
[2]Senior Consultant

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ABSTRACT

Although lumbar instability is considered to be responsible for the majority of chronic or recurrent low back pain, the word ‘instability’ is still poorly defined. A biomechanically more accurate definition of segmental instability, using a ‘neutral zone’ concept has been proposed. To measure the radiological sagittal translation (in mm) and sagittal angulation (in degrees) in flexion and extension x-rays of the lumbar spine of the patients and to identify patients with sagittal translation >3 mm and sagittal angulation >10 degrees (patients with Lumbar Instability). To assess the prevalence of lumbar instability among patients with low back pain The present study was a Observational Cross-sectional Study. This Study was conducted from June 2017 to March 2019 at Department of Apollo Gleneagles Hospital, Kolkata Neurosurgery OPD. In patients with lumbar instability, the mean MODI score (mean±s.d.) of the patients was 59.2500±13. 6899. In without lumbar instability, the mean MODI score (mean±s.d.) of the patients was 47.9730±12. 0979. Distribution of mean MODI score vs. Group was statistically significant (p = 0.0013). The incidence of lumbar spinal instability in patients with LBP at our tertiary care hospital was found to be significant. These findings suggest that radiographic assessment of spinal instability should be considered in the diagnostic workup for LBP, particularly in patients with chronic symptoms or those unresponsive to initial treatment. Further research is needed to explore the implications of these findings for treatment outcomes and patient management strategies.

INTRODUCTION

Although lumbar instability is considered to be responsible for the majority of chronic or recurrent low back pain, the word 'instability' is still poorly defined. A biomechanically more accurate definition of segmental instability, using a 'neutral zone' concept has been proposed by Punjabi *et al*.[1]. The neutral zone concept is based on the observation that the total range of motion (ROM) of a spinal motion segment may be divided in two zones: A neutral zone and an elastic zone. The neutral zone is the initial portion of the ROM during which spinal motion is produced against minimal internal resistance. The elastic portion of the ROM is the portion nearer to the end-range of movement that is produced against substantial internal resistance. Segmental instability is thus defined as a decrease in the capacity of the stabilizing system of the spine to maintain the spinal neutral zones within the physiological limits in order to prevent neurological deficit, major deformity and/or incapacitating pain.

At the most simple level, instability is a lack of stability, a condition in which application of a small load causes an inordinately large, perhaps catastrophic displacement.

The clinical definition of instability is: 'a condition in which the clinical status of a patient with low back problems evolves, with the least provocation, from the mildly symptomatic to severe episode[2]. Others consider instability to exist only when sudden aberrant motions such as a visible slip or catch are observed during active movements of the lumbar spine or when a change in the relative position of adjacent vertebrae is detected by palpation performed with the patient in a standing versus palpation performed with the patient in a prone position[3].

The stabilizing system of the spine can be conceptualized as consisting of passive (inert) and active (contractile) parts and a neural control system. These three subsystems maintain spinal stability both in neutral and extreme positions.

The passive subsystem consists primarily of the vertebral bodies, zygapophyseal joints and joint capsules and spinal ligaments. The passive subsystem plays its most important stabilizing role in the elastic zone of spinal ROM (i.e. near end-range) and numerous studies have been conducted that demonstrate the relative contributions of passive structures to segmental stability[4].

The posterior ligaments of the spine (interspinous and supraspinous ligaments) along with the zygapophyseal joints and joint capsules and the intervertebral discs, are the most important stabilizing structures when the spine moves into flexion. End-range extension is stabilized primarily by the anterior longitudinal ligament, the anterior aspect of the annulus fibrosus and the zygapophyseal joints, rotational movements of the lumbar spine are stabilized mostly by the intervertebral discs, the zygophyseal joints and for the L4-L5 and L5-S1 segments, the iliolumbar ligaments too[5].

The active subsystem consists of muscles and tendon and provides active voluntary or reflex stabilization. Unisegmental muscles such as intertransversarii and interspinalis, located near the intervertebral centre of rotation act as transducers sending information to the neural control subsystem for motion and position controls. Plurisegmental muscles such as abdominal muscles and erector spinae produce and control movements of the lumbar spine.

The neural control subsystem includes the various transducers and the neural control centres. The transducers provide information to the control centres that determine the requirements to achieve stability.

MATERIALS AND METHODS

Study area: Apollo Gleneagles Hospital, Kolkata.

Study design: Observational cross-sectional study.

Period of study: June 2017 to March 2019

Inclusion criteria:

- Age group between 18 and 80 years of age
- All cases of spondylosis and spondylolisthesis
- All patients presenting with low back pain with or without associated radiculopathy.

Exclusion criteria:

- Patients with associated spinal diseases like TB, Metastases
- Patients with traumatic fracture of lumbar spine.
- Acute traumatic lumbar disc prolapses
- Patients with Spondylisthesis grade IV and V

Sample size: 61

Statistical analysis: For statistical analysis, data were initially entered into a Microsoft Excel spreadsheet and then analyzed using SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism (version 5). Numerical variables were summarized using means and standard deviations, while categorical variables were described with counts and percentages. Two-sample t-tests, which compare the means of independent or unpaired samples, were used to assess differences between groups. Paired t-tests, which account for the correlation between paired observations, offer greater power than unpaired tests. Chi-square tests (χ^2 tests) were employed to evaluate hypotheses where the sampling distribution of the test statistic follows a chi-squared distribution under the null hypothesis; Pearson's chi-squared test is often referred to simply as the chi-squared test. For comparisons of unpaired proportions, either the chi-square test or Fisher's exact test was used, depending on the context. To perform t-tests, the relevant formulae for test statistics, which either exactly follow or closely approximate a t-distribution under the null hypothesis, were applied, with specific degrees of freedom indicated for each test. p-values were determined from Student's t-distribution tables. A $p \leq 0.05$ was considered statistically significant, leading to the rejection of the null hypothesis in favour of the alternative hypothesis.

RESULTS

In patients with lumbar instability, the mean MODI score (mean±s.d.) of the patients was 59.2500±13. 6899. In without lumbar instability, the mean MODI score (mean±s.d.) of the patients was 47.9730±12. 0979. Distribution of mean MODI score vs. Group was statistically significant (p = 0.0013) (Table 1).

In patients with lumbar instability, the mean duration of symptoms (mean±s.d.) of the patients was 39.0000±23.2716 months. In without lumbar instability, the mean duration of symptoms (mean±s.d.) of the patients was 29.1351±33.9388 months. Distribution of mean duration of symptoms vs. Group was not statistically significant (p = 0.2180).

In patients with lumbar instability, 5(20.8%) patients had LBA± T&N and 19(79.2%) patients had LBA+NC. In patients without lumbar instability, 15(40.5%) patients had LBA±T&N and 22(59.5%) patients had LBA+NC. Association of symptoms vs. Group was not statistically significant (p = 0.10921). Association of co-morbidities vs. Group was not statistically significant (p = 0.3522) (Table 2).

DISCUSSION

Low back pain is a common problem in the general population. Causes of low back pain are varied. Javadian *et al*.[6] in a randomized controlled study

Table 1: Distribution of mean MODI Score, Duration of symptoms in months vs. Group

Modi score	Number	Mean	SD	Minimum	Maximum	Median	p-value
Lumbar Instability	24	59.2500	13.6899	40.0000	90.0000	59.0000	0.0013
Without Lumbar Instability	37	47.9730	12.0979	16.0000	70.0000	48.0000	
Duration of symptoms in months							
Lumbar Instability	24	39.0000	23.2716	12.0000	96.0000	30.0000	0.2180
Without Lumbar Instability	37	29.1351	33.9388	1.0000	120.0000	24.0000	

Table 2: Showing association of symptoms, co-morbidities vs. Group

	Groups			
	Lumbar instability	Without lumbar instability	Total	p-value
Symptoms				
LBA, NC	19	22	41	0.10921
Row (%)	46.3	53.7	100.0	
Col (%)	79.2	59.5	67.2	
LBA, T&N	5	15	20	
Row (%)	25.0	75.0	100.0	
Col (%)	20.8	40.5	32.8	
Total	24	37	61	
Row (%)	39.3	60.7	100.0	
Col (%)	100.0	100.0	100.0	
Co-morbidities				
CAD	1	0	1	0.3522
Row (%)	100.0	0.0	100.0	
Col (%)	4.2	0.0	1.6	
DM	1	2	3	
Row (%)	33.3	66.7	100.0	
Col (%)	4.2	5.4	4.9	
DM, HTN	5	2	7	
Row (%)	71.4	28.6	100.0	
Col (%)	20.8	5.4	11.5	
HTN	6	8	14	
Row (%)	42.9	57.1	100.0	
Col (%)	25.0	21.6	23.0	
HTN, DM, HYPO	0	1	1	
Row (%)	0.0	100.0	100.0	
Col (%)	0.0	2.7	1.6	
HYPO	0	1	1	
Row (%)	0.0	100.0	100.0	
Col (%)	0.0	2.7	1.6	
None	11	23	34	
Row (%)	32.4	67.6	100.0	
Col (%)	45.8	62.2	55.7	
Total	24	37	61	
Row (%)	39.3	60.7	100.0	
Col (%)	100.0	100.0	100.0	

attributed excessive vertebral translation and rotation in sagittal plane to be causative factor of lumbar segmental instability and low back pain.

Various criteria for measuring lumbar segmental instability has been used by different researchers. The most common criteria that can be measured radiographically has been the magnitude of sagittal translation and angulation. However, till date there is no consensus among the authors about the cut-off value beyond which the motion segment should be diagnosed as having a lumbar segmental instability. Different authors have proposed different sagittal and angulation measurements beyond which to classify as having segmental lumbar instability. Iguchi *et al.*[10] proposed >3 mm sagittal translation and >10° angulation as having lumbar instability.

Punjabi and white have put forward a 4 mm sagittal translation anteriorly or 2 mm sagittal plane translation posteriorly and sagittal/rotational angulation of >15° at L1-L4, >20° at L4-L5 and >25° L5-S1 levels as suggestive of lumbar instability.

Knutsson defined instability as 3 mm or more of anterior translation measured between flexion and extension[7]. Boden and Wisel emphasized that any slip should be greater than 4 mm before instability could be considered. Dupuis et al. suggested >4 mm of sagittal translation or 15% of vertebral body width and >10° of sagittal angulation as indicative of lumbar instability[8].

In our study the mean of sagittal translation (mean±s.d.) was8.8750±6.0456 mm and mean of total in degrees sagittal angulation (mean±s.d.) of the patients was 32.7500±13.6931° which are above the cut off value proposed by Dupuis *et al.*[8], White and Punjabi[9], Tetsuhiro *et al.*[10], Boden and Wisel[11] and Jang *et al.*[12].

Golbakhsh *et al.*[13] found that the overall incidence of segmental instability was 10.5% at L3-L4, 16.5% at L4-L5 and 7.3% at L5-S1. DD (disc degeneration) and LFH (ligamentum flavum hypertrophy) at L3-L4 and FJO (facet joint osteoarthritis) and LFH at L4-L5 were individually associated with segmental instability (p<0.05). Incidence of segmental instability was higher at L4-L5 (p<0.05) when compared to other segments. However, they found that L3-L4 segment level was involved next to L4-L5 level.

In our study the lumbar instability was found to be more at L4-L5 level (16 out of 24 cases i.e., 67 %), followed by at L5-S1 level (7 out of 24 cases i.e., 29%) and 1 case (4%) at L2-L3 level. The mean sagittal and angular translation at each segment was calculated separately. Both the parameters were found to be highest at L4-L5 segment. This finding was in accordance with Tamrakar *et al.*[14].

Rathod *et al.*[15] found a more sagittal orientation of facet joints at L4-L5 level in the degenerative spondylolisthesis group, when compared to with those without lumbar spondylolisthesis. This sagittal orientation facilitates vertebral slippage when other predisposing factors are present. They proposed that because of the coronal orientation of L5-S1 facet joints, the majority of degenerative spondylolisthesis occur at the L4-L5 level which was also found in our study as well.

Pitkänen *et al.*[16] found angular rotation to have negative correlation with age, while sagittal translation did not show any consistent correlation with age. Neither had any significant correlation with sex. There was negative correlation of sagittal translation with age in our study. In our study the value of R was -0.1373. The result is *not* significant at p<0. 05. There was positive correlation between Age vs Total (in degrees) Sagittal Angulation. The value of R was 0.1828. The result was *not* significant at p<0.05. There was negative correlation between Age vs translation in mm in neutral position. The value of R is -0.1487. The result is *not* significant at p<0.05.

Kaiser *et al.*[17] found that degenerative spondylolisthesis (p = 0.004) at L3-4 level and (p = 0.017) at L4-5 level in univariate analysis and odds ratio 16.92 at L4-5 level in multiple logistic regression analyses and spondylolytic spondylolisthesis (p = 0.003) at L5-S1 level in univariate analyses were the strongest independent determinants of anterior sliding instability. Retrolisthesis (odds ratio 10.97), traction spur (odds ratio 4.45) and spondylarthrosis (odds ratio 3.20) at L3-4 level were statistically significant determinants of posterior sliding instability in multivariate analysis. Sliding instability is strongly associated with various plain radiographic findings. In mechanical back pain, functional flexion-extension radiographs should be limited to situations when symptoms are not explained by findings of plain radiographs and/or when they are likely to alter therapy.

Of the 24 patients with lumbar instability only 4 (16.66%) patients had non-spondylolisthesis in neutral x-ray. 19 out of 24 patients (79.17%) had spondylolisthesis grade I and 1 patient (4%) had spondylolisthesis grade II. 4 (16.7%) patients had spondylolysis spondylolisthesis (3 patients at L5-S1 level, 1 Patient at L4-L5 level). However, there were 3(8.1%) patients who had pars defect without radiographic lumbar instability (2 at L5-S1 level and 1 at L4-L5 level).

Fritz *et al.*[18] studied the frequency of radiographic instability of sixty patients with structural pathologies of the lumbar spine with dynamic lumbar radiographs. Of these 60 patients 76% presented some grade of instability. 60% of this instability was angular (60% in the affected segment and 40% in the adjacent) and 16% translational. Segmental instability was highly prevalent in both but more in angular than translational planes.

Fritz *et al*.[18] examined the relationship between clinical presentation and the presence of radiographic incidence of lumbar instability in 49 patients with low back pain. Twenty-eight patients (57%) had radiographic instability. Their patients had a mean age of 39.2 (±11.3) years, with a mean Oswestry score of 20.4% (±13.3). The median duration of symptoms was 78 days.

In our study out of 61 patients that were examined and evaluated, 24 patients (39.3%) had radiographic instability and 37 (60.7%) patients did not have radiographic instability.

In lumbar instability, the mean age (mean±s.d.) of the patients was 51.9583±13.8391 years. In patients without lumbar instability, the mean age (mean±s.d.) of the patients was 48.0811±11.5575 years. Distribution of mean age vs. Group was not statistically significant (p = 0.2412).

In patients with lumbar instability, the mean duration of symptoms (mean±s.d.) of the patients was 39.0000 ± 23.2716 months. In patients without lumber instability, the mean duration of symptoms (mean±s.d.) of the patients was 29.1351±33.9388 months. Distribution of mean duration of symptoms vs. Group was not statistically significant (p = 0.2180).

On comparing the MODI score (Modified Oswestry Disability Index) between those with lumbar instability and those without lumbar instability, the mean MODI score (mean±s.d.) was 59.2500±13.6899 and 47.9730±12.0979, respectively. The mean MODI score was higher in patients with instability and statistically significant (p = 0.001). This means, the patients with lumbar instability had more disabling symptoms that affected their routine life as compared to those without lumbar instability.

In patients with lumbar instability, 10(41.7%) patients were female and 14(58.3%) patients were male. In those without lumbar instability, 14(37.8%) patients were female and 23(62.2%) patients were male. Though males were affected more than the females in the two groups (with and those without lumbar instability), there was no statistically significant association between the sex and the groups (p = 0.7649).

In patients with lumbar instability, the mean duration of symptoms (mean±s.d.) of the patients was 39.0±23.2716 months. In those without lumbar instability, the mean duration of symptoms (mean±s.d.) of the patients was 29.1351±33.9388 months. Distribution of mean duration of symptoms vs. Group was not statistically significant (p = 0.2180). Out of 24 patients with radiographic instability 19 (79%) patients had symptoms suggestive of neurogenic claudication and only 5 patients (20.83%) did not have these symptoms. Association of symptoms versus group was not statistically significant which was in concordance with the studies done by other researchers.

In the follow up period, none of the patients without lumbar instability operated (discectomy, laminectomies) for various causes showed any evidence of radiographic instability. No new radiographic instability was also seen in those operated for lumbar instability (spinal fusion ± pedicular screws & rod fixation). Patients in both the groups showed improvement in their MODI score when compared to their pre-operative MODI score.

CONCLUSION

Dynamic x-rays (lateral flexion-extension views) still remains the investigation of choice to detect spinal lumbar instability because it is cheap and easily available. The mean of the sagittal translation and angulation obtained in our study is well above the cut-off value criteria for lumbar segmental instability set by the researchers who have used dynamic lumbar x-rays to investigate lumbar instability. We can very confidently state that >3 mm of sagittal translation and >10° sagittal angulation in the combined lateral flexion and extension x-rays of the lumbar spine is good enough criteria to label a patient with low back pain with or without radiculopathy as suffering from lumbar instability.

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